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How Much Employment Can Rapid Agricultural Growth Generate? – Sectoral Policies for Maximum Impact in Rwanda

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Preface

This work outlines a strategy for achieving high agricultural growth in Rwanda and discusses the probable impacts of that growth on employment and poverty reduction. In particular, it details the input and commodity composition for achieving a high growth rate in agriculture. This strategy aligns with the Government of Rwanda's basic emphasis on commercialization and intensification as the twin pillars of accelerated agricultural growth as well as the commodity priorities delineated by the Parliament. The publication proceeds from determining the components of a high agricultural growth rate to calculating the impact of that growth on employment. Emphasis is on the indirect effects on rural non-farm employment, and comparison with the impact of urban formal sector growth on employment.

The next publication in this series entitled "The Impact of Agricultural Growth on Employment in Rwanda: A Three-Sector Model" (Mellor and Ranade, 2002a) takes an alternative approach to calculating the impact of agricultural growth on employment. The neo-classical three-sector model predicts somewhat higher growth rates for employment and for all sectors except agriculture, than do the estimates presented this paper. We presume that agriculture grows more slowly in the model because its dynamic nature allows labor to be pulled out of agriculture. Despite this difference, the three-sector model supports the analysis presented here and has the additional benefit of allowing for simultaneity.

The third paper in this set, entitled "Productivity-Increasing Rural Public Works – An Interim Approach to Poverty Reduction in Rwanda" (Mellor 2002), accepts the employment growth numbers of the growth accounting framework. However, it starts from an assumption of substantial unemployment in the rural sector. That assumption reflects the disruptions of the past decade. It assumes an eleven-year, massive decline in unemployment due to agricultural growth as calculated in the basic paper. It then postulates a rural public works program that absorbs the remaining unemployed after five years of rural public works expansion. The rural public works scheme phases out over the next five years during which agricultural growth allows for the absorption of labor released from the discontinued rural public works program. The benefit of the rural public works is not only a much more rapid decline in poverty than would otherwise be possible, but an immense increase in rural capital. That increase is essential to the continued progress of the agricultural revolution set forth in the basic paper.

The three papers differ in their assumptions about unemployment in the following manner and for the following reasons. Rural unemployment is unusual even in low-income countries. In Rwanda, rural unemployment is the consequence of the extreme disruptions of the past decade. Mellor (2002) accepts that there is a large pool of unemployed labor, and deals with the issues of how rural public works can absorb it in the short run.

The other two papers in effect assume a Rwanda like that of the pre-genocide period or that of several years in the future after the temporary pool of unemployed has been absorbed. In this paper, it is assumed that although there is no unemployed labor that the supply of labor is perfectly elastic. That is, that as the demand for labor increases the demand will be met with negligible increase in real wages. This assumption is justified by the very low marginal productivity of labor and the consequent potential for minor shifts in the way it is used to allow for increases in the quantity of labor. Mellor

and Ranade (2002a) uses a three-sector neoclassical model that assumes labor is freely allocatable across sectors. The real wage rises with increased demand. So while the treatment of the wage varies between this paper and its companion three-sector model, the basic conclusions related to growth and employment generation are surprisingly similar.

Four other papers are critical complements to this paper. Two are by Gunvant Desai (2002a and 2002b) who lays out the requisites for rapid growth in fertilizer use, assesses progress over the past two years, and a makes a set of recommendations. In the high-agricultural-growth scenario outlined by Desai, fertilizer accounts for 75 percent of incremental growth. The other two are by Frans Goossens (2002) who analyzes the needs for absorbing rapid growth in potato production and by Charles Crissman (2002) who assesses progress to date with respect to potato production and marketing and provides recommendations for action for both the short run and the long run. In Crissman's high-agricultural-growth scenario, potato is the most responsive crop to fertilizer use and has the highest growth rate. Crissman, therefore, makes a strong case for improved potato marketing. Thus, these four papers deal with two critical components of the strategy to achieve high agricultural growth in Rwanda.

Executive Summary

How can Rwanda achieve broad geographic participation in development, rapid employment growth, and reduced poverty? In Rwanda, those objectives lead one to examine the rural sector, which employs 90 percent of the population and more than 90 percent of the poor. Large statistical studies across countries and time show that rural growth reduces poverty greatly and urban growth does so only minimally. Similarly, agricultural growth reduces poverty immensely and growth in the manufacturing sector does not.

Urban poverty is a function of migration from rural areas as a response to immense rural urban income differentials. Raising urban incomes and amenities, simply increases the rush of poor, rural people to urban slums. In the rural sector, the poor derive income largely from rural non-farm employment. The goods and services they produce are non-tradable. Since producers of rural non-tradable goods cannot engage in export of their typically low-quality goods, the primary source of demand for their output is local farm income.

Prospering farmers in low-income countries spend about 20 percent of incremental income on labor-intensive livestock and horticultural products and 40 percent on rural non-farm goods and services (Mellor 1995, Bell and Hazell 1980, Hazell and Roell 1983). Rich landowners, on the other hand, typically spend incremental income on imports and capital-intensive manufactures (Timmer, 1997). It is the peasant farmers' purchases of locally-produced, labor-intensive items that generate employment. The work of Dharm Narain, discussed in Mellor and Desai (1985), shows a lag between the rise in farm incomes and poverty reduction. This is consistent with the indirect nature of the effect of agricultural growth on poverty reduction.

This study proposes a target agricultural growth rate of 5.3 percent and furthermore, suggests that this has the capacity to generate a 6.7 percent rate of growth in the linked rural non-farm sector. We presume that growth in agriculture stands not only on yield increases, but also on increasingly productive labor. Because some of the growth is generated by yield improvements, a 5.3 percent rate of growth of agricultural output is associated with only a estimated 3.2 percent of employment growth. However, we suggest that this same agricultural sector growth stimulates a 6.7 percent growth in employment in the labor-intensive rural non-farm employment. Paired with similar analysis for the urban sectors, this analysis suggests that 88 percent of incremental employment is generated by agriculture (with two-thirds of that located in the rural non-farm sector stimulated by agriculture).

How can agriculture be made to grow so rapidly in Rwanda? The Ministry of Agriculture is on the right track with their twin pillar mandate of intensification and commercialization. The extraordinarily depleted, but responsive, soils of Rwanda offer opportunity for achieving a 5.3 percent growth rate largely from increased use of fertilizer.[1] Indeed, our estimates suggest that 75 percent of our agricultural growth target can be realized with fertilizer alone. The swamp reclamation program would provide another 9 percent of the growth and the rest accrues through more intensive farming.

To reach these targets, the Government of Rwanda must ensure widespread demonstrations that bring farmers rapidly into fertilizer use and convince private importers and retailers that a market exists.

[1] See Cook (2002a), Desai (2002a) and Desai (2002b).

Concentration in a few of the most responsive provinces and commodities will bring quick, convincing results, that are essential to the rapid spread of fertilizer to other regions and commodities.

This study suggests that potato and coffee and tea have the potential to achieve 20 percent and 15 percent annual growth, respectively. Potato can grow that quickly because the response to fertilizer is startlingly high, farmers already have some knowledge of fertilizer use on potato, there is scope to expand cultivated area. Moreover, the concentration of the area under potato cultivation provides economies of scale to the private sector. Similarly, tea and coffee are also highly responsive to fertilizer and can grow rapidly by just regaining past levels of production. Difficult and persistent problems must be solved in the context of privatization.

To realize these benefits requires vigorous government action (including expenditure). Large scale on-farm demonstrations must be staged, market information and analysis systems are needed, export markets must be analyzed, credit systems developed, roads expanded, and the whole system monitored. The private sector needs support if it is to perform. As fertilizer becomes more widely utilized on the most profitable crops, its use will spread to other crops. The Ministry of Agriculture has an important role in accelerating that process.

As a closing reminder, smallholder agriculture requires far more expenditure on public goods than does large-scale urban industry if it is to prosper and drive poverty reduction. It needs: investment in rural roads and telecommunications, adaptive research, demonstration programs, credit systems, market information, and much more. Continued neglect will perpetuate the growing poverty that characterizes Africa. Rwanda is en route to being a much-needed African success story. However, a future success story requires vigorous private activity and intelligent complements from the government. It would be immensely helpful if foreign aid played the same leadership role that it played decades ago in Asia.

Introduction

How to achieve broad geographic participation in development, rapid employment growth, and reduced poverty are the subjects of this paper. In low-income countries, those objectives immediately leads one to examine the rural sector. In low-income countries, 75 percent of the poor are in rural areas. In Rwanda, 90 percent of the total population, and more than 90 percent of those living in poverty, reside in the rural space.

Urban poverty in low-income countries is a direct function of the rural-urban income disparity. The greater that disparity, the more rapidly impoverished rural people will migrate to urban areas. Because of the relatively higher capital intensity in urban areas, wage rates are much higher in urban manufacturing than in rural areas. Urban slums develop as these migrants chase after a small number of well-paid jobs in the urban areas.[2] Thus, perhaps paradoxically, an important element in the solution to urban poverty lies in raising rural incomes. It is not accidental that urban poverty has virtually disappeared in Asia, where agriculture has done well, and has burgeoned in Africa, where agriculture has performed poorly and foreign aid has swelled urban income and amenities.

Within the rural sector, it is the population that garners income from non-farm activities that typifies the bulk of the poor. As will be shown later, it is rising farm incomes that provide the effective demand for increased rural non-farm production and employment. Thus, agriculture is the engine of rural growth, employment increase, and poverty reduction. Without rising farm incomes, efforts to increase rural non-farm incomes only redistribute the poverty, but do not reduce it.

Agriculture is dominated by low-income small entrepreneurs who depend on accelerated technological change and expanding markets for high-value commodities to mitigate the constraint of its limited land area. The Government of Rwanda has fully recognized this and has made the intensification and commercialization of agriculture central to its strategy for the agricultural sector. Agriculture also requires large investment in physical infrastructure if it is to commercialize, intensify with improved technology and take advantage of enlarging markets. Similarly, investment in rural education and rural health is needed.

Thus, far more than any other sector, agriculture depends on public goods for its growth, not only to support its own direct production but also to complement private sector efforts to service agriculture. Government investment, institution building, and policy are critical to rapid growth of smallholder agriculture.

However, given tightly constrained public sector resources, narrow priorities must be set for what public goods are most critical and timely, and resulting public actions must complement those of the far larger private sector. To accomplish this, a consensus on a national strategy with priorities and an appropriate plan of action must be attained.

[2] These relationships are discussed in a very old, but still classic paper by Harris and Todaro (1970).

Five Why's of Agriculture, Employment, and Poverty

Five questions are posed here and further discussed below.

1. Why does poverty reduction require rapid growth in farm incomes to provide effective demand for rural non-farm goods and services?

2. Why must agriculture grow faster than domestic markets will sustain if it is to play a key role in poverty reduction?

3. Why does rapid growth in agriculture require massive growth in inorganic fertilizer use as the number one priority?

4. Why do scale economies in fertilizer supply require an initial geographic concentration of agricultural growth?

5. Why is action by the Government of Rwanda, and specifically the Ministry of Agriculture, so important to agricultural growth?

In treating these issues, succeeding sections will present data to show:

a. How to generate an agricultural growth rate over five percent per annum.

b. How such agricultural growth has the potential to generate growth of the rural non-farm sector of nearly seven percent.

c. How in the context of rapid growth of all sectors, agriculture has the potential to generate 88 percent of employment growth (which is far greater than its share of GDP growth).

d. And, how 66 percent of the employment growth that is stimulated by rapid agricultural growth is in the rural non-farm sector.

But, before proceeding to the data for Rwanda, perspective can be gained from the factual record from other countries.

Agriculture, Employment, and Poverty Reduction - The Data

The relationship between agricultural growth, employment growth, and poverty reduction is complex, and therefore frequently misunderstood. However, the data clearly show the strength of this relationship across time.

India has detailed statistics of poverty levels and agricultural growth. These data cover highly diverse geographic areas and are comparable over long periods of time. Careful statistical analysis by Ahluwalia (Ahluwalia, 1978), Narian as discussed in Mellor and Desai (1985), and interpretation by Mellor (1995) shows clearly that when agricultural production per capita grew, poverty declined.[3] However, up until the

[3] The converse also holds.

mid-1970s, India's agricultural production per capita fluctuated with the weather. When the weather was good, poverty declined and when it was bad, poverty increased. But, what about long term trends when agriculture steadily grows?

By the mid 1990's, there had been a substantial period of steady growth in India's per capita agricultural production; which varied considerably among states, as well as among different sectors. Guarav Datt and Martin Ravallion of the World Bank's Research Department, analyzed those data and found that: (1) rural growth markedly reduced poverty overall and in rural areas, (2) rural growth reduced urban poverty more than did urban growth; (3) urban growth had little effect on poverty reduction; and, (4) agricultural growth was powerful and manufacturing growth weak in reducing poverty (Datt and Ravallion, 1998). Ravallion and his colleagues analyzed data for several other Asian countries and corroborated the powerful role of agriculture in poverty reduction (Ravallion, 1995).

At about the same time, Peter Timmer and his colleagues at Harvard University took advantage of the rapid growth under varied circumstances in the developing world and analyzed cross-national data over time (Timmer, 1997). Their results, using quite different data and statistical methods, corroborated the work of Ravallion and colleagues. Given this evidence, a strong association between agricultural growth and poverty reduction is firmly established. Is there logic to this relationship?

Agriculture, Employment and Poverty - Causal Relationships

It is large increases in per capita agricultural income that drive poverty reduction. Some of that increased income goes directly to very poor farmers who own little land. But, most of the land, even in smallholder agriculture, is in the hands of farmers who have enough income from land that they are not poor by the usual definitions. Those more prosperous farmers spend the bulk of that additional income locally, partly on high-value, agricultural products such as horticulture and livestock, but even more so on locally-produced, non-farm goods and services.

The bulk of the rural poor earn most of their income from employment — in part working on other peoples' land, but more from producing rural non-farm goods and services. When farmers prosper, they hire more labor to reduce the labor provided by children, spouses and other family members. Prospering farmers also make capital investments to their houses, buy local furniture and clothing, and demand domestic transport, and other local services.

Typically, farmers spend 20 percent of incremental income on labor-intensive agricultural commodities such as horticulture and livestock products and 40 percent on locally produced non-farm goods and services (Mellor, 1995, Bell and Hazell, 1980, Hazell and Roell, 1983). These goods and services cannot be exported because of high transaction costs and poor quality. Therefore, if production and employment are to increase in the rural non-farm sector, local demand must increase (Delgado et. al., 1998). Agriculture must grow substantially faster than population growth to have these favorable effects, because they depend on rising per capita incomes.

Work by Ravallion and Timmer also show that increased agricultural incomes do not reduce poverty if land ownership is highly unequal. In such circumstances, the income from agriculture is concentrated in the hands of a few very wealthy persons (who may actually reside in the capital city) who consume little of rural non-farm goods and services. Their incremental consumption consists mainly of imported goods or capital-intensive domestic manufactures. Such consumption patterns produce little demand for rural

non-tradable commodities and hence little incremental employment, except that which is directly in farming.

Similarly, the Ravallion and Timmer data, as does the earlier work by Narian (discussed in Mellor and Desai, 1985) show several-year lags before the full effect of agricultural production is felt in poverty reduction. That is consistent with the indirect nature of the process, which must work through increased demand for the rural non-farm sector, and through that on employment, and eventually on wage rates. When employment rises enough to raise wage rates the poor benefit doubly, from more hours of work and from higher returns per hour worked.

Common sense tells us about the above relationships. Ask persons in rural non-farm employment what years they are prosperous and the answer will be when weather is good, providing a bountiful harvest and more money in farmers' pockets. The same relationship holds for steady growth in farm incomes from agricultural development.

In summary, agricultural income per capita rise when rapid improvement in crop yield-increasing technology occurs or when new markets open up for high-value agricultural commodities. Those events drive increases in agricultural production that raise farm income rapidly. Higher farm incomes in turn drive rapid growth in the rural non-farm economy.

Past Experience in Rwanda

Unfortunately, in Rwanda, there is evidence that these potentially positive dynamics also work in reverse. From the early 1980's, soil fertility gradually declined as intensive cropping drained nutrients from the soil without replacement. Farm incomes declined in response. Concurrently, the lower production of biomass and decline in livestock numbers associated with lower incomes resulted in less organic matter being available as well. Many environmentalists believe that if organic matter is adequate then commercial fertilizer is not needed. In fact, organic matter and nutrients from commercial fertilizer are complements. The decline in organic matter is partly the direct result of the general decline in nutrient content of the soils and a related decline in livestock numbers.

As farmers' incomes declined, farmers reduced the use of hired labor and substituted family labor. They consumed more and more of what they produced and marketing declined, as did the purchasing power to buy non-farm goods and services. The result was rapidly declining employment in the rural non-farm sector. To the rural non-farm population, the reduced purchasing power of farmers mimicked the decline experienced by farmers in years of bad weather. The culprit was not weather in this case but declining incomes due to declining soil fertility driven in turn by policies that made fertilizer unavailable to farmers. It is not uncommon for social tensions to rise in such circumstances.

What are the Conditions for Rural Prosperity in Rwanda?

Succeeding sections of this paper describe the potential composition of a high growth rate in Rwanda's agricultural sector. The growth rate will be discussed in terms of the input requirements, the commodity composition of growth, and the vital government actions that are needed to activate and complement private sector action. Then, data will be presented showing how the agricultural growth converts into rapid growth in the rural non-farm sector and even faster growth in employment in that sector. The

relative importance of the agricultural and urban formal sectors as engines of employment growth will be described.

Sources of Rapid Growth in Rwanda's Agriculture

If agriculture is to play a major role in poverty reduction it must grow rapidly. In fact, it must grow substantially more rapidly than the population. Producing sufficient food for a growing population is not enough. What is needed is rapidly rising farm incomes that provide the purchasing power to drive employment in the rural non-farm sector. Thus, rapid agricultural growth is needed, partly because substantial employment is created within agriculture, but much more because higher agricultural incomes are needed to provide the effective demand for the rural non-farm sector.

There are three requirements for such rapid growth: (1) technological change that increases yields of crops and livestock at a pace that requires application of modern science; (2) low transaction costs based on all-weather roads, telecommunications, and sophisticated market development; and, (3) export commodities that will allow production to grow faster than domestic demand. Each of these requirements has its own prerequisites of private-sector activity and complementing government action.

Rwanda has highly responsive, but greatly depleted, soils that provide extraordinarily high rates of return to inorganic fertilizer. The fertilizer supply must expand rapidly and farmers must be educated in its use. Since inorganic and organic fertilizers are complements, it will also be necessary to restore livestock production and utilize the increased biomass from increased soil fertility. In the short run, the capacity for research to keep technological change moving must be built so that growth can continue into the long run. Investment in soil and forest conservation will become increasingly profitable as modern science increases crop yields.

Rwanda has poor infrastructure in rural areas. In the short run, large increases in production can occur where infrastructure already exists; in the long run, that infrastructure must be expanded. That will require massive investment.[4]

Rwanda has major export crops in tea and coffee that can grow quickly in the short run by simply returning to past levels of production and using suitable land for further expansion. Potato production can also grow rapidly in the short run and serve the East African market. Other horticultural crops such as pyrethrum have potential for growth in the intermediate run.

Input Sources of Growth

What are reasonable targets for agricultural growth? The following section lays out what we suppose to be the three most probable sectors of growth and their potential contribution to agricultural expansion.

Fertilizer

Dr. G. M. Desai, at the USAID-sponsored fertilizer workshop held by the Ministry of Agriculture in February 2001, suggested a ten-year target of increasing fertilizer use from the 8,000 tons of 2000, to 65,000 tons, and to do so initially in annual increments of 5,000 tons per year increments, the size of

[4] See Mellor (2002).

those annual increments gradually increasing over time (Desai, 2002a). The fertilizer potential is so great because of lack of use of fertilizer in the past, a commensurate unusual decline in soil fertility, and hence the scope for very high rates of return as fertility is restored.

Currently, most of Rwanda is trapped in a low-level equilibrium vis-à-vis fertilizer. Farmers do not use fertilizer because it is not available. The private sector is not providing fertilizer because farmers do not use it – that is, the expected volume of sales is too low to justify the fixed costs of bringing in fertilizer.

Kelly et. al. (2002) examined fertilizer trials for specified crops and agronomic conditions. Normally it is thought that farmers require an increased value of output twice the cost of the fertilizer to justify its cost and perceived risk. Kelly et. al. used a far more conservative value of incremental output of three times the fertilizer cost. Those calculations showed such high profitability for 23,000 tons on crops in areas covering six percent of the land. Tea and coffee were excluded from the analysis but are highly responsive to fertilizer.

Thus, the fertilizer target suggested by Desai seems quite feasible on economic grounds. In the year following the fertilizer workshop, fertilizer use grew ahead of target for the crops other than tea and coffee. Those two stalled immediately because of institutional failings in the respective parastatals. Subsequently growth in use on tea and coffee has not picked up and use on other crops has slackened. Use has dropped despite the rapid expansion in the number and size of fertilizer importers. The difficulty now seems to be on the side of farmer knowledge of fertilizer and the practices required to accompany its use (Desai, 2002a and 2002b). That problem can only be solved by a massive program of fertilizer demonstrations. Demonstrations have been expanding, but not nearly rapidly enough to meet the fertilizer targets. More importantly, the demonstrations have not been targeted to crops and areas with a high response to fertilizer. As a result, many of the demonstrations have not proven profitable (Desai, 2002a and 2002b). That is a discouraging example for farmers.

Area Expansion and Intensification

The World Bank is financing a major program for greatly intensifying the use of large areas of swampland that are now only extensively cultivated. The increase in production is so large that it is analogous to bringing in new land and is so treated in the following calculations. The swamp intensification program will bring 40,000 hectares of prime agricultural land into intensive production over a ten-year period. That is the equivalent of a 0.5 percent rate of growth in cultivated area.

Increasing profitability of crops on reclaimed land with attendant irrigation and fertilizer use, as well as the opening of export markets, will allow a shift of crop production area from low-value crops, such as cassava, to high-value crops, such as Irish potato, horticulture, and tea and coffee. Intensive livestock production will also greatly increase with the more intensive farming of this land.

The intensification is an ancillary benefit from fertilizer. Without the large increase in profitability made possible by high levels of fertilizer use the shift to more intensive crops would not occur. Increased fertilizer use is also vital to the expanded land area, since the substantial costs of swampland intensification can only be covered if the high yields associated with fertilizer use are realized.

Table 1 shows the impact of the projected fertilizer use, swampland intensification, and shift in cropping pattern to higher value crops. The growth rate attained is 5.3 percent per year, which is the average for fast agricultural growth countries (Mellor, 1995). However, those fast-growth countries are in general

middle-income developing countries with more developed institutional structures to support high growth rates.

Table 1

Target Agricultural Growth Rate, by Source

Sources of Growth	Percentage points of growth	Percent of agricultural growth
Fertilizer	4	75
Area Expansion	0.5	9
Intensity of Crops	0.8	16
Total	5.3	100

[a] See appendix for explanations.

Sources: Author's estimates, but also see appendix for sources.

Rwanda can be expected to perform at a level more akin to the middle-income developing countries because of the unusual scope for catch-up growth (simply emulating what has already been done elsewhere). We propose catch-up growth that is concentrated on a single input, fertilizer, and a small set of crops, including potato, tea, coffee, and vegetables.

The feasibility of achieving a high agricultural growth rate in Rwanda depends on three sets of commitments by the GoR: (1) to commercialization and intensification; (2) to first concentrate maximum effort where expected success is greatest and then to proceed to more difficult situations through learning by doing; and, (3) to provide maximum scope to the private sector while simultaneously providing public sector complements.

Table 1 shows that under the foregoing assumptions, 75 percent of the incremental agricultural growth can be attributed to fertilizer; 16 percent is due to shift of area from low-value subsistence crops to higher-value commercial crops; 9 percent is from expansion in area, which is simply taking the World Bank swampland intensification project and converting it into percentage increase in area.

The impact of production area increase shows that, even in Rwanda, expansion is still possible and adds a critical element to overall production growth. Agricultural growth at the population growth rate of 2.5 is quite easy to achieve. Increased labor input and very modest, perhaps locally generated, improvements in technology can achieve that. An additional 2.8 percent of incremental growth is difficult. Area growth of 0.5 percent represents nearly one-fifth of that increment. Thus, while the swampland intensification element of the World Bank project is only a portion of a much larger project, it plays a vital role in the increment that drives poverty reduction.

Commodity Sources of Growth

The output mix in agricultural growth is determined by the interplay of the market-driven forces of supply and demand. Market forces will largely determine the commodity composition of growth rate. Why then estimate the growth rates commodity-by-commodity? Certainly the purpose is not to provide government

with targets that are to be met by fiat, subsidies, other non-market forces, or even manipulation of the data. Rather, as for any private business, a high growth rate requires many efforts with long lead times. Research is a good example. Much of those efforts are crop specific. Thus, some estimate of the likely commodity composition of growth is essential to achieving high growth rates.

Although achieving a high overall growth rate of 5.3 percent will be mainly the accomplishment of the private sector, private actors require key public goods as complements. Given the scarcity of public sector resources, some estimates have to be made as to where and how to concentrate them.

For example, the high responsiveness of potato to fertilizer calls for: concentration of fertilizer demonstrations in potato areas; monitoring of private sector fertilizer retail markets in respective areas to ensure adequate expansion; and careful monitoring of potato production to ensure the markets are expanding at least as rapidly as the supply. It is now clear that potato varieties will have to be changed to those that ship and store better than current varieties and that meet consumer tastes in increasingly more distant markets. In addition, initially spreading demonstrations evenly all over the country will dissipate the critical mass necessary to provide incentives to retailers. The rapid growth in potato production may initially catch the wholesalers unaware with precipitous decline in prices, then in production, institution of a potato cycle, and great delay in long-term growth. Immediate action is needed to provide the critical public goods essential for avoiding that outcome.

Table 2 presents estimates by commodity that sum to the 5.3 percent growth rate presented in Table 1. The commodity estimates of growth presented are based on the responsiveness of crops to fertilizer, the geographic concentration of those crops, and the present level of commercialization. These are commodity growth rates consistent with the sources of growth by inputs analysis.

Five different growth rates are assumed. The differences are commodity specific and based on estimates of the potential responsiveness of each crop to fertilizer as estimated by Kelly et. al., the potential to export as judged by past behavior, the size of nearby regional markets, and the demand elasticity in the domestic market. The various rationalizations for these estimates follow.

The highest growth rate assumed, is an extraordinarily high rate of 20 percent per year for potato. That doubles production every 3.5 years. This high growth rate is based on the very high response to fertilizer shown by Kelly et. al. Those returns run as high as 8 times the value of incremental output attributable to the fertilizer.

The concentration of potato production in a few districts ensures that all the requirements of rapid growth are met. Over 70 percent of Rwanda's potatoes are produced in two provinces. Farmers have had some experience with fertilizer on potato. There is already a moderate density of demonstrations in the major potato areas and those could readily by expanded to cover every district in the two largest producing provinces. Since only 3.8 percent of the value of agricultural production is represented by potato, there is also scope for rapid growth in area as profitability is increased by fertilizer use.

A very high growth rate of 15 percent per year is shown for tea and coffee. This rate can be achieved over the next several years simply by releasing the constraint on fertilizer supply from cash constraints on the parastatal importers. That might be done by providing credit for off lending to farmers with repayment by both farmers and parastatals at harvest time. Although coffee prices are low, the crop still provides higher returns to Rwanda farmers than most alternative crops. Tea is profitable now. Both crops are still produced at levels far below pre-genocide levels so there is much scope for catch-up growth. There are,

of course, problems in the transition to private sector operation. So far, the potentials for tea and coffee are not being realized.

Table 2

Target Agricultural Growth Rate, by Commodity, Rwanda

Crop	Target Growth Rate (%)	Contribution to the Value of Agricultural Production (%)	Contribution to Agricultural Growth (%)
Potatoes	20	3.8	14
Tea/Coffee	15	2.6	7
Livestock	8	13.0	20
Vegetables/Fruit	8	13.0	20
Cereals	5	3.6	3
Beans	5	3.3	3
Sweet Potato	4	4.9	4
Banana	3	34.7	20
Other	3	14.2	8
Other Roots/Tubers	1	6.9	1
Total	5.3	100	100

[a] See appendix for explanations of calculations.

Sources: Author's calculations, but also see appendix for sources.

A high growth rate of 8 percent is assumed for both horticulture and livestock. When per capita incomes grow consistently with high agricultural growth, we estimate that domestic demand will absorb about 90 percent of the increments to production of livestock and about 80 percent of fruits and vegetables. This suggests about 10 percent of the increment in livestock and approximately 20 percent of the increment to production of fruits and vegetables must be absorbed in exports or import displacement over the long run. In the short run, while domestic incomes are still slow to pick up, a substantially higher proportion will need to be sold in the export market. For livestock, import displacement can probably do the job for the first few years, until domestic income comes up to speed. That may well be true of horticulture as well.

The high-growth strategy depends on a 5 percent growth rate for beans and cereals. Kelly et. al. (2002) show high response to fertilizer for pole beans and for most of the major cereals. Domestic demand will absorb that increment given that there will be substantial substitution for less-favored caloric sources such as root crops. Within cereals, rice will grow much more rapidly than 5 percent, balancing a somewhat lower rate for the lower quality cereals. Maize and sorghum will need to grow at that 5 percent rate to meet the feed demand of the high livestock growth rate shown. It would not be surprising if the area in cereals contracted somewhat in the face of large response to fertilizer and high returns to the major cash crops.

Sweet potato is projected to grow somewhat slower than the basic cereals, reflecting some substitution for inferior roots. Kelly et. al. (2002) show that sweet potato is highly responsive to fertilizer. We expect that as fertilizer use on commercial crops grows, it will leak over into the responsive food crops. Thus, this growth probably represents little increase in area.

Bananas and crops in the "other" category are presumed to experience growth that is slightly higher than population growth at 3 percent. Kelly et. al. (2002) have no data for the responsiveness of banana to fertilizer. However, FAO data regarding fertilizer application on commercial banana crops in Central America suggests a high rate of return. This growth rate assumes a slow decline in area planted.

Finally, for other roots and tubers a one percent rate of growth is projected, with modest yield increase and therefore significant decline in area.

In summary:

(1) Over 80 percent of the growth comes from five commodities sets: bananas, vegetables/fruits, livestock, potatoes, and tea/coffee. The initial commodity focus for policy should be potato and tea/coffee. Although they only account for 21 percent of the production increase, they will respond more readily than other crops. Hence, the growth may be concentrated on them initially and then spread out to the somewhat more difficult commodities.

(2) Banana, even assuming a rather slow growth rate still ranks with the top three commodity sets in terms of incremental production. That is because initially over one-third of all agricultural output is attributable to banana. The banana crop demands significant attention from public policy.

(3) Both vegetable/fruit and livestock require rapid growth in overall incomes before the high growth rates shown will be feasible, but the groundwork for their rapid growth needs to be laid now.

(4) Potato is the prime candidate for immediate production increase because of its extraordinary responsiveness to fertilizer and its geographic concentration. Concentration will facilitate a simple demonstration program and profitable opportunities for the private sector in input supply and marketing.

Feasibility of the Fertilizer Supply Growth

Table 3 details an indicative plan for phasing in the annual growth of 5,000 tons of fertilizer use over two years. It takes the current coffee and tea fertilizer-use levels and increases them at 15 percent per year, consistent with the growth rate projected for coffee and tea. Even at this rate of growth, prior levels of production will not be surpassed for several years. Of course, a prerequisite is the satisfactory completion of the privatization process. The plan then allocates much of the remainder of the fertilizer increase to: 1) the two major potato-producing districts, 2) Kigali Rural, and 3) the other districts in only very modest amounts. The purpose of this exercise is to show that a major impact is possible even when it is concentrated in two provinces. After allocating for coffee and tea, roughly two-thirds of remaining incremental fertilizer is slated for Ruhengeri and Gisenyi. Why is that assumption made?

Table 3

Indicative Plan for Annual Increments of 5,000 Tons of Fertilizer Materials
Two-year phase-in, concentration in Ruhengeri, Gisenyi, and Kigali-Rural, 2000-2006
(in tons and percentages)

Item	Base 2000	Phase-in 2001	Phase-in 2002	2003	2004	2005	2006
Total imports	8000	10000	13000	18000	23000	28000	33000
Annual increments		2000	3000	5000	5000	5000	5000
Percent increments		25%	30%	38%	28%	22%	18%
Coffee & tea	5400	6210	7150	8200	9400	10800	12400
Annual increments		810	940	1050	1200	1400	1600
Percentage increments		15%	15%	15%	15%	15%	15%
Ruhengeri (R) & Gisenyi (G) provinces							
Potato	1300	2100	3200	5200	6200	7450	8950
Vegetables	200	250	300	350	400	450	500
Maize/other	0	100	450	900	1350	2000	2750
Total	1500	2450	3950	6450	7950	9900	12200
Increment		950	2100	2500	1500	1950	2300
R & G as percent of total (excluding coffee & tea)	58	65	68	66	58	58	59
Kigali-rural	200	240	500	1450	2650	3700	4700
All other provinces	900	1100	1400	1900	3000	3600	3700

[a] See appendix for notes on these estimates.

Sources: Desai (2002a), Cook (2002a), Cook (2002b) and author's calculations.

The great success stories of Asia provide several lessons. First, the breakthroughs in production were concentrated on a few places and on a few commodities that garnered high returns. Second, with concentration, a critical mass in production became possible, which in turn provided scale economies to private sector input suppliers and output marketers. Third, with that core of success, the impact spread rapidly out from those areas. Fourth, public support for agricultural growth requires dramatic proof of the potential for success. Initial concentration bolsters the probability of dramatic success. The purpose is not to concentrate growth, but to provide those scale economies necessary to grow and then expand. That is all the more important since Rwanda must rely, more than was the case in Asia, on the private sector for input supplies and critical marketing services.

Table 5 shows that the targets for the two major provinces can be met by starting with the larger farmers. By the fourth year, we suggest that as many as two-thirds of the potato farmers with 0.5 to 0.75 hectares in Ruhengeri and Kisenyi could have adopted fertilizer use. A similar story is shown for the other commodities and for Kigali Rural (Tables 5 and 6).

As discussed at length in this paper, the most important impact of agricultural growth on employment is through expenditure by farmers on the rural non-farm sector. Within the generally small farmer context of Rwanda it will not lessen those effects if the growth is concentrated on the larger farmers. It should be noted that in Asia, innovation, particularly including fertilizer use, spread fully to the small farms within two years of rapid adoption. Moreover, the small farmers used fertilizer at heavier doses than the large farmers. Why do we suggest a different story for Rwanda? Because, in Asia, the rural credit systems were highly developed even before the Green Revolution. In Rwanda, those systems are still quite rudimentary.

Table 4

Characteristics of Farms in Ruhengeri and Gisenyi

	<0.5 Ha	0.5-0.75 Ha	0.75-1.0 Ha	1-2 Ha	2+ Ha	Total
Farm area	31	20	15	23	11	100
Household	64	17	9	9	1	100

Sources: Mpyisi (2001).

Table 5

Recommended Percent of Area Fertilized, Ruhengeri/Gisenyi, by farm size and crop

Crop	<0.5 Ha	0.5-0.75 Ha	0.75-1.0 Ha	1-2 Ha	2+ Ha	Weighted average	Percent of all households
Potato Base 2000	0	5	24	24	24	13	5
2001	0	10	39	39	39	21	9
2002	0	25	57	57	57	32	21
2003	0	50	85	85	85	52	24
2004	0	65	100	100	100	62	30
2005 & 2006				Same as 2004			
Maize 2006	0	10	65	65	65	34	14

[a] See appendix for notes on these recommendations.

Sources: Author's recommendations based in part figures in Table 4 extracted from Mpyisi (2001).

Table 6

Recommended Percent of Area Fertilized, Kigali-Rural, 2006, by farm size and crop
(numbers in parentheses refer to recommended tone)

	<0.5 Ha	0.5-0.75 Ha	0.75-1.0 Ha	1-2 Ha	2+ Ha	Weighted average	Percent of all households
Vegetables (250)	100	100	100	100	100	100	100
Potato (650)	100	100	100	100	100	100	100
Maize (950)	100	100	100	100	100	100	100
Bean (1200)	0	20	20	20	20	10	7
Sorghum (1540)	0	0	45	45	45	22	9

[a] See appendix for notes on these recommendations.

Sources: Author's recommendations based in part figures in Table 4 extracted from Mpyisi (2001).

It is inconsistent with equity concerns to leave small farmers out of this process. However, to include them requires urgent attention to developing rural credit systems. It is also important to long-term growth. Table 5 projects that when the 23,000 ton target is met by 2004, only 30 percent of potato farmers in Ruhengeri and Gisenyi will adopt fertilizer, covering 62 percent of the land. Thus, more than one-third of the land would be left out of the process. Growth would be more rapid if that land were included. That requires credit programs on a large scale. However, the push for increased production should not wait for those credit programs. In the meantime, the larger farmers will increase their incomes, spend heavily in the rural non-farm sector, and have a major impact on increasing employment and reducing poverty.

Feasibility of Marketing the Increased Potato Production

Achieving scale economies for fertilizer suppliers and breaking from the current low level equilibrium trap for fertilizer requires an initial concentration of effort in the two northwest provinces and in effect on potato. In the illustrative commodity breakdown of a 5.3 percent growth, potato production is targeted to double in 3.5 years. It is clear in the exposition that in any case a substantial portion of agriculture must grow faster than can be absorbed in domestic markets if the high growth target is to be reached. Marketing doubled production in 3.5 years must appear a daunting task as first glance.

However, FAO (2000) statistics indicate that at present Rwanda's potato production is only 13 percent of the region's production (Table 7). Thus a 20 percent increment in Rwanda's production only adds 2.6 percent to regional production. At most, that should bring a few percentage points reduction in prices, which should be easily absorbed by Rwandan farmers who would be experiencing very sharp reduction in cost of production. The immense increase in yields caused by highly profitable fertilizer use will sharply reduce the cost of production of potato.

Further, Rwanda's highest potato production in the past was 2.5 times present production. That must have been substantially marketed outside Rwanda. Part of the task, therefore, is simply to recover old markets. In the short run, a substantial proportion of production must be shifted to varieties that store and transport better than present varieties. The marketing task will become more difficult in three or four years time. By then, progress needs to be made in grading and packaging, storage, and eventually in processing.

The preceding sections discuss the various means by which Rwanda can achieve a 5.3 percent agricultural growth rate. How then is that converted into rapid increase in the demand for labor and reduction of poverty?

Table 7

Potato Production, Regional African Countries (1990-2000)

Year	Burundi	Congo	Kenya	Rwanda	Tanzania	Uganda	Total regional production	Production in Rwanda as % of regional production
1990	44,500	33,280	241,884	319,000	240,000	224,000	1,102,664	28.9
1991	45,500	34,010	173,915	445,000	220,000	254,000	1,172,425	38.0
1992	46,700	35,000	159,218	347,000	200,000	268,000	1,055,918	32.9
1993	45,500	36,000	184,529	204,159	220,000	320,000	1,010,188	20.2
1994	32,398	38,000	162,484	149,070	230,000	368,000	979,952	15.2
1995	41,567	37,000	204,942	137,700	240,000	402,000	1,063,209	13.0
1996	42,385	48,000	270,000	195,381	245,000	318,000	1,118,766	17.5
1997	48,596	62,000	376,612	229,625	240,000	360,000	1,316,833	17.4
1998	23,655	55,000	380,000	181,138	250,000	384,000	1,273,493	14.2
1999	24,393	50,000	350,000	175,889	255,000	449,000	1,304,282	13.5
2000	24,039	50,000	360,000	175,000	255,000	478,000	1,342,039	13.0

[a] See notes in appendix.

Source: *FAO (2001)*

What Does This Agricultural Growth Do For Employment?

The poor are lifted out of poverty almost entirely by increased employment. The poor have little capital or land. They have abundant labor, but relatively little human capital to enhance the productivity of that labor.

Because agriculture is so large, high rates of agricultural growth do create substantial employment in agriculture. But this growth in employment is nowhere nearly proportional to the output growth. High yielding crop technology increases both labor and land productivity. Thus, a ten percent increase in agricultural production will provide no more than a six percent increase in employment and often does no more than a four percent increase in employment (e.g. Rao, 1975). However, the benefits to the poor will be somewhat greater than that implies, since in low-income countries, prospering small farmer agriculturalists substitute hired labor for family labor, particularly with respect to children and wives, so that landless laborers get an extra impact.

Much more important than the direct employment in agriculture, small farmers spend the bulk of their incremental income locally (e.g. Mellor, 1995, Bell and Hazell, 1980). That has a major impact on employment for the following reasons.

The rural non-farm sector is large, producing a wide variety of goods and services, including construction (particularly of farmers houses and additions to their houses), furniture, garments and textiles, a wide range of utensils, transport services, and, most important, a wide variety of services.

The goods and services produced by the rural non-farm sector are largely non-tradable. They cannot be sold in foreign markets because of high transaction costs (e.g. transport and marketing) and low or inappropriate quality. That means that local demand, which is driven by agricultural income, is the only important form of demand. The local tailor, lacking local demand, cannot sell in the couture houses of Paris, not yet at least. This is an extremely important fact, given contemporary emphasis on exports and export markets as a basic engine of economic growth. Those markets are directly important to agricultural growth, but they cannot be directly important to growth in the rural non-farm sector.

Rural non-farm activities are very labor intensive. They use little land or capital in production. Typically they are far more labor intensive than even such export activities as the export garment industry. They are not only labor intensive, but technology tends to change only slowly so that employment expands almost as rapidly as output. That is in contrast to both urban large-scale industry and to agriculture.

The sectors that are dominant in employment increase are far less important to increments in GDP. If the focus is only on GDP growth, employment growth, and hence poverty reduction, will suffer. That is not to say that employment growth occurs in sectors of low efficiency. The relationship between employment growth and GDP growth is simply a reflection of employment intensity. The less labor-intensive sectors require more capital and land in production, so the contribution to GDP reflects major returns to those factors of production

From these principles, it becomes clear that agriculture reduces poverty indirectly through rising farm incomes and their expenditure on the rural non-farm sector. It is clear from the earlier exposition that trade is important to achieving high agricultural growth rates. But trade alone cannot solve the basic problems of employment and poverty.

Table 8 applies the preceding principles to basic data for Rwanda. Notes to the tables, annexed at the end of the paper elaborate on the derivation of the numbers in Table 8. The economy is divided into a rural and an urban sector. The rural sector is divided into a farm sub-sector and a non-farm sub-sector. The urban economy is divided into a formal or large-scale sector and a non-formal or small-scale sub-sector. A rural economy in equilibrium will demonstrate rather little overt unemployment. Rather, poor people in particular will search for employment, and at the worst carry out gathering activities, e.g. grass for livestock, that provide at least some income. At present, the major disruptions in the rural economy of Rwanda result in substantial open unemployment.

The report on rural public works makes a division of the rural non-farm population into those employed in rural non-farm activities and the open unemployment. The latter is calculated as about 14 percent of total labor force, or about one-third of the rural non-farm population. The calculations in Table 8 do not make that division, hence they are more representative of the situation prior to the genocide or that which will prevail when equilibrium in the rural labor force is reached through some recovery in the commercialization and intensification of agriculture. The report on rural public works proposes a program to bridge that gap and in the process provide essential rural public works.

Table 8

Potential Employment Growth Assuming High Agricultural GDP Growth, Rwanda

Sector	% of GDP	% of employment	GDP growth	% of GDP growth	Elasticity of labor to GDP growth	Employment growth	% of employment growth
Rural							
Tradable (farm)	40	44	5.3	34.0	0.6	3.2	30.0
Non-tradable (non-farm)	25	46	6.7	26.0	0.9	6.0	58.0
Subtotal (weighted)	65	90	5.8	60.0	0.7	4.3	88.0
Urban							
Tradable (formal)	33	5	7.0	37.0	0.4	2.8	3.0
Non-tradable (non-formal)	2	5	9.2	3.0	0.9	8.3	9.0
Subtotal (weighted)	35	10	7.6	40.0	0.5	6.0	12.0
Total/Weighted Average	100	100	6.4	100.0	0.8	5.0	100.0

[a] See notes in appendix on assumptions underlying these estimates of potential GDP and employment growth.

Sources: Author's calculations based on MINECOFIN (2000) and MINAGRI (2001).

In Rwanda, 90 percent of the labor force is rural and only 10 percent urban. Somewhat less than half the rural population is farmers (full-time equivalents) and somewhat more than half is non-farm. That non-

farm sector derives its demand from farmers and from itself -- i.e. the rural non-farm sector produces for itself as well as for farmers. But, the initial stimulus to income comes from farmers and then the rural non-farm people spend some of that increased income on each other as well as outside the sector, including for food.

While the rural non-farm sector is larger than farming in employment, its share of GDP is substantially less. That is a reflection of its labor intensity, compared to agriculture where much of the return from output is a return to land rather than to labor. The rural non-farm sector is driven by agricultural incomes. The demand elasticity of farmers for rural non-farm goods and services is high, about 1.5 (Mellor, 1995). Hence, the rural non-farm sector grows faster than agriculture, even though agriculture is the engine of its growth. Similarly, for the urban non-formal sector.

In the urban sector, half the labor force is in the non-formal sector and half in the formal sector. But the formal sector has over 16 times as large a proportion of GDP. That reflects the high capital intensity in the formal sector. The capital intensity is high even in the export sectors, but is even higher in key support areas such as electric power.

Table 8 presents data consistent with these assumptions and calculates employment growth rates and proportion of incremental employment by sector. The striking finding is that in Rwanda, given high growth rates of 5.3 percent presented earlier for agriculture, and 7 percent for the urban formal sector, and derived growth rates for the rural non-farm (6.7 percent) and the urban non-formal sector (9.2 percent), 88 percent of incremental employment will result from the direct and indirect effects of agricultural growth. And the indirect effect through demand for the rural non-farm sector is nearly twice as important as the direct employment in agriculture itself. That is because the rural non-farm sector is highly employment intensive, it expands faster than agriculture because of the high income-elasticity of demand for its products, and it tends not to increase labor efficiency much as it expands.

It should be noted that the proportion of incremental employment by sector is a function of the base size of the sector, the growth rate of that sector (and the growth rate of effective demand for that sector), and the incremental employment intensity of the sector. Alternatives to agriculture for generating employment initially have less favorable coefficients for each of these variables. It is only after a considerable period of rapid growth that they can begin to have an aggregate impact. That is particularly true in Rwanda where all the alternatives start from an extremely small base.

An Action Plan for Employment Increase and Poverty Reduction

The basic engine of employment growth and poverty reduction is increased farm incomes. As derived from analysis by Mellor, Timmer and Ravallion, that holds for a smallholder agriculture, which certainly fits Rwanda. Although increased incomes may commence in the hands of the already more prosperous of small farmers, that does not decrease the efficacy of the employment impact. That is because even those with large holdings by Rwandan standards are still small farmers who are fully integrated into their rural communities. In Rwanda, that is fortunate because of the early stage in development of rural credit systems that are so essential in reaching the smallest farmers.

If agriculture is to be the initial engine of growth, output must grow more rapidly than domestic demand, requiring export markets for a portion of incremental output. For Rwanda, that means emphasis on coffee and tea, on potato, and eventually on horticulture. Specialty crops such as pyrethrum may also play a role.

However, the initial emphasis must be on crops that can have a large aggregate impact. As the process gets under way, incomes in the economy as a whole will rise, creating rapidly increasing demand for livestock and horticulture, both of which provide increased intensity.

Initially a success is needed. That is why the first priority in Rwanda must go to fertilizer, where the magnitude of the income increase is immense. The emphasis needs to go to the most fertilizer responsive crops, of which potato is the prime example. But, coffee and tea also respond well and generate cash income to pay for the fertilizer. The private sector needs scale economies to wholesale and retail fertilizer, as does the government to operate demonstrations. Thus, one concentrates initially in a small number of highly responsive provinces. As they succeed, the demonstration effect will help in expanding to full national coverage.

Since the concentration is on a few commodities and provinces, marketing problems are likely to arise. Thus, there must be close monitoring of markets. In Asia, the initial breakthrough was on cereals and the governments guaranteed markets and prevented sharp price declines in the face of large increases in production volume. Now, such government action is frowned upon. The substitute must be diagnosis of impending surpluses and encouragement of the private sector to purchase for export in the region and beyond in sufficient quantities to be competitive and thus to hold down margins and thereby enhance price incentives to farmers. Asian experience shows that there are important public goods needs to complement the private sector – particularly including information flows.

The symbiotic relation between private and public sector activity is important. There is capital and entrepreneurship in the private sector ready to respond to profitable opportunities. However, the private sector tends to be trade oriented (looking for fast turnover) at this stage in Rwanda's development, and risk averse. Because of poor infrastructure, it is reluctant to take the risks associated with working in remote areas.

Thus, the public sector has an important role to play in fertilizer supply by demonstrating the profitability and the size of the market to both farmers and potential fertilizer suppliers; by increasing competition in output marketing, documenting the approach of large production increases (as for potato), and publicizing the need for rapid expansion of trading activity. More generally, the private sector will eventually invest in expanding markets, but at this stage it is more likely to respond to markets that have already been established. The government must constantly account for bottlenecks in the processes of rapid agricultural growth and encourage the private sector to step in to break those bottlenecks. For this, well-developed information systems are essential.

Rwanda as a Success Story for Africa

Africa desperately needs some success stories. Of course, most of African agriculture that grew rapidly in the 1960's was largely led by the export commodities -- so there is some history of large-scale success. Striking small-scale successes also exist, e.g. smallholder tea production in Kenya. But now there are few ongoing success stories. That is because of change for the worse in policies following the great successes of the 1960's

Rwanda is the logical candidate for a contemporary success story. Initial successes must come from the easier situations, not the most difficult. Rwanda has soils and climate highly responsive to high input levels and modern crop varieties. Rwanda is off on the right foot in its emphasis on commercialization

and intensification. It has sound basic macro policies. It has relatively open trading arrangements with neighboring countries.

Five years of rapid agricultural growth would tighten labor markets, raise incomes of the poor markedly, and provide a broad pattern of dispersed urbanization as market towns prosper.

Such a success would boost morale in both African countries and in the door community.

Appendix: Notes To Tables

Table 1

Fertilizer

The target stated is to reach 65,000 tons of materials in ten years. In Rwanda, fertilizer use is normally expressed in tons of materials. Eventually the transition should be made to expressing in nutrients, as is generally done outside of Africa. In general, when fertilizers are used in Rwanda, the tonnage of nutrients is about half the tonnage of material, with a base year usage of about 5000 tons. The total increment is about 60,000 tons, or 30,000 tons of nutrients (Cook 2001a). The average annual increment would be 6000 tons of material. From Table 3, it is planned in two years to get to annual increments of 5000 tons, and then to gradually increase sufficiently to make the 60,000 tons increment in ten years. The 65,000 tons of material or roughly 32,500 tons of nutrients will bring Rwanda to the still extraordinarily low level of 19 kg of nutrients per hectare of total cultivated land. Soils would on average continue to be depleted of nutrients with each successive crop!

A fairly standard rule of thumb for assessing production impact of fertilizer is 10 kg of cereal output per kg of nutrient (Mellor and Lele, 1965). At the low levels of fertilization that would prevail in Rwanda, even after the 60,000 ton increment, a response of 13 to 1 would still be conservative. This figure is well below the average response given in the Kelly et. al. calculations, and would provide the four percent increments to output from fertilizer shown in Table 1 (Kelly et. al., 2001, Clay et. al., 2001). Thus, the annual increments to output would be 39,000 tons of cereal equivalent. In the early years, the annual increment would be 32,500 tons of cereal equivalent.

The average yield of cereals per hectare in Rwanda is now about 0.48 tons, as calculated from the Ministry of Agriculture Statistics for total area and total tonnage of cereals produced during Season A (Mpyisi et. al. 2000). Applying that to the total area planted for Seasons A and B of 1,705,078 provides 818,437 tons of cereal equivalent. Four percent increment to that, the figure used in Table 1, is 32,737 tons of cereal equivalent.

Area Expansion

The total area cropped in Rwanda is 1,705,078 hectares (MINAGRI, 2001). The World Bank swampland intensification project aims to bring 40,000 hectares of currently extensively farmed swampland under intensive cultivation with well-controlled water. With double cropping, that is 80,000 hectares or a 4.7 percent increase in cropped area, over ten years, or 0.47 percent per year. Compounded annually, the rate would be somewhat less. Because this land is anticipated to be more productive than average, we can round that up to 0.5 percent. Strictly speaking, this is not new land being brought under cultivation, but since it is extensively used due to very poor water control, and, yields after the improvements will be very high, we treat it as though it were new land.

Increased Intensification

The indicative target of adding 0.8 percentage points to the annual growth rate would be achieved if 0.8 percent of the land area were transferred to a use that doubled the value of output. That sounds quite modest. However, presently about 9 percent of the area is in the sum of vegetables, tea and coffee, and Irish potato, the major candidates for increase in area of intensification. That area would have to grow

nearly 10 percent per year to achieve the 0.8 percent shift of total area. That is quite rapid. Table 2 in effect projects a 10 percent annual rate of increase in potato area after the first few years, and 8 percent in vegetables and fruits. Rice production will probably grow quickly with the swamp water control program, but the initial base is very small.

The proportion of incremental output from fertilizer will increase corresponding to how intensification and area expansion fall short of the targets. Thus, this exercise underlines how important fertilizer increase is to meeting employment and poverty targets. It is probably understated rather than overstated.

Table 2

It is clear from Table 1 and Table 6 that achieving the fertilizer target is essential to meeting the agricultural growth rate needed for substantial poverty reduction. In contrast, the growth rates for specific crops in Table 2 are indicative only. The precise composition of commodity growth rates will depend on the following: price ratios driven substantially by international markets, growth in domestic demand for the non-tradable portion of agricultural output, including the majority of horticulture and livestock sub-sectors, the relative pace of technological change, and of course, domestic policies, with respect to potato trade, privatization of tea and coffee, technology transfer, and so on.

However, these notional indicators are necessary for planning public action to support both the small-scale private sector farmers and suppliers. Actions can include: demonstrations, for farmers and fertilizer suppliers alike, concentrated in areas where a critical mass for scale economies may be achieved; research, focused on those crops most likely to find adopters and markets; and road investment, in areas of breakthrough fertilizer introduction and marketing demand.

Production increase is commodity specific, even in cases in which clusters of commodities may increase due to complementarities in their production.

The commodities in Table 2 are ordered by the rate of increase in output. The weighted average of those rates of increase sums to the 5.3 percent shown in Table 1 analyzing inputs; thus there is consistency between the two tables. The four commodity sets with the highest growth rates contribute in total 61 percent of the total increment.

Potato

The highest commodity growth rate is shown for potato, at 20 percent. That would not be possible if potato occupied a higher proportion of the area and value of production. Potato production is concentrated in the two northwestern provinces, which collectively account for 62 percent of potato area in 2000 for Season A and B (MINAGRI, 2001). Potato is one of the most responsive of the crops to fertilizer. It has good market opportunities (see below). Thus it is ideally suited to provide an initial success story, to provide a base for pushing out to national coverage, and to solve the problem of the current lower level equilibrium trap in fertilizer supply.

Potato production was about 175,000 tons in 2000; less than 40 percent of its 1991 level (FAO, 2001). Thus, potato production can increase by 2.5 times and not exceed the previous high point. The 20 percent annual growth rate will achieve the previous high in four years time. By then, systems should be in place for marketing, input supply, and technology, to maintain that rate of growth for several years, with the shift of area into potato comprising half of the output increase.

Tea/Coffee

In 1999, coffee production was one-third the pre-genocide level peak. Currently, coffee prices are extraordinarily low. However, personal interviews with coffee producers made clear that they have no good alternative for a cash crop. Low cost quality improvement will raise farm prices substantially. Indeed, in Butare and elsewhere new plantings are going in at a rapid rate (personal observation, May, 2001). Coffee is receiving a small fraction of the optimal fertilizer dosage (Cook, 2001b). Thus, all the conditions are ripe for the 15 percent target growth rate. That will require attention to grower needs for inputs and improved marketing, particularly small washing plants to raise quality. Reaching this level will certainly not happen automatically, but it is clearly feasible.

Markets should not be a problem with such a rate of growth given that Rwanda has potential for the best quality. Of course, that requires attention to the requisites of quality including significant new investment.

Livestock and Vegetables/Fruits

In the short run, livestock and vegetables/fruits share very limited export potential, however, perishability and transport costs provide a naturally protected domestic market. The income elasticity of demand for these products is very high. Thus, rising incomes will increase demand rapidly.

Given a population growth rate of 2.5 percent; GDP growth of 6.4 percent as shown in Table 3 and an income elasticity of demand of 1.5 results in an 8.35 percent rate of growth in domestic demand. in livestock (2.5 + 1.5(6.4 - 2.5) = 8.35).

Ministry of Finance (MINECOFIN) data show population growing at 3 percent at present and the labor force at 2.7 percent (MINECOFIN, 2000). The death rate is currently 22 and the birth rate 46, implying a population growth rate of 2.4. Thus, taking 2.5 as a rounded approximation seems reasonable.

The income elasticity is consistent with FAO data for similar countries.

At present, Rwanda substantially imports livestock products. Thus, import substitution can create effective demand while the growth rate of per capita income picks up.

Rwanda's livestock numbers on crop or mixed farms are still far below pre-genocide numbers. The demand for adding livestock, both small and large ruminants, is strong. Livestock are complements to inorganic fertilizer, given the extremely low levels of organic matter in the soil, and the extreme current scarcity of organic matter. Asian countries typically have met domestic livestock demand increases at this level (Mellor, 1995). Thus, such an important place for livestock is evident.

Meeting this high growth rate in production will require technical assistance for improving feeding and breeding of livestock, private investment in marketing, and expansion of intermediate term credit facilities. A high proportion of the increment to livestock production must come from intensive management of livestock on crop farms. Thus, concentrate feeding will be high. Improvement of breeds to facilitate intensive feeding will become increasingly important, as will the complementary improvement in veterinary services.

Vegetables/fruits probably face a somewhat lower income elasticity of demand than for livestock. In the preceding livestock equation, an elasticity of 1.0 should be substituted for the 1.5 for livestock providing a rate of domestic demand growth of 6.4 percent. Thus, to meet the target of 8 percent growth requires that about 20 percent of incremental production be exported, or about 1.6 percent of total production. Some exports can go to surrounding countries, treating the regional market as one. That will take care of the short run, while domestic incomes increase. In the longer run, it is certain that Rwanda has good export markets in Europe and the Middle East. However, these markets require vigorous private sector development, including technology transfer, and, most importantly, expansion of air transport to reliable daily service from the present at best moderately reliable biweekly service.

Cereals and Beans

Cereals and beans are projected to grow at 5 percent per year. That is a rapid rate of growth. However, most of the cereals (rice, sorghum, maize) are highly responsive to fertilizer (Kelly et. al., 2001, Clay et al., 2001), so yield can be readily increased and area may expand at the expense of the low value root crops.

It is doubtful that Rwanda has a comparative advantage in cereal exports (absorbing export parity prices instead of import parity prices). Domestic demand probably has a moderately high (e.g. 0.5) income elasticity of demand at present but it is unlikely to average higher than 0.3 over the next several years. Thus, domestic demand for human consumption should grow at about 3.7 percent per year. The residual, or one quarter of incremental production or an increment equal to 1.3 percent of total production, can be diverted to livestock feed. That is probably an understatement of livestock feed needs, with stall feeding of livestock, increasing animal productivity, and an 8 percent growth rate in livestock production.

Pole beans are highly responsive to fertilizer, demand is more elastic than for cereals, and they can move readily to export markets (Kelly et. al., 2001). Thus, a five percent growth rate seems achievable on both demand and supply grounds.

Sweet Potato

A quite high four percent growth rate is shown for sweet potato. Sweet Potato has a strong response to fertilizer (Kelly et. al., 2001, Clay et al., 2001), is preferred as a food to other roots and tubers, and is grown in good soils. A four percent growth rate assumes an income elasticity of demand of 0.38, on the order of that for cereals. That will undoubtedly drop over time and the sweet potato growth rate can be expected to decline from four percent after a few years. That will most likely occur through decline in area.

Banana

Production growth barely above population growth is assumed for banana. It is notable that although no data are available from the FAO trials or even recent research at ISAR, banana elsewhere is highly responsive to fertilizer. As an indication, the world average for banana fertilization is 496 kg per hectare of nutrients, compared to 283 for sugar another unusually responsive crop. At the end of ten years the targets set here will bring Rwanda to 19 kg per hectare for all crop area!

Despite the slow growth rate, Banana would account for 20 percent of incremental production, the same as livestock and vegetables/fruits, and 50 percent more than potato with its extraordinary growth rate of

20 percent, and three times the increment of tea/coffee. That high proportion of total growth is because of the very large weight of banana in current production - over one-third of the value of output. Thus, a high agricultural growth rate must at least in the short run have a prominent place for banana.

Other Crops and Other Roots/Tubers

Other crops are targeted at a little above the population growth rate, implying slow decline in area. Roots and tubers other than white and sweet potato are assumed to decline substantially in area with only a minimal one percent increase in production.

Table 3

Table 3 provides a notional view as to how an incremental 5000 tons of fertilizer material would be absorbed, after a two-year phase in period. The purpose is to illustrate the feasibility of reaching the targets and the efficiency of an initial concentration on two high productivity provinces.

The total imports for 2000 and the levels for OCIR The and Cafe are from Cook (2001b). It is assumed that utilization on tea/coffee will grow at 15 percent per year. This is conservative given the OCIR tea/coffee estimates that current usage is only one-third the economic optimum and the targeted growth rate of 15 percent. However, difficult problems associated with privatization will have to be solved to achieve these targets. It is of course crucial to employment growth that those problems be solved.

Cook estimates from interviews with importers that currently about 60 percent of all fertilizer used in Rwanda is used in the two provinces of Ruhengeri and Gisenyi (Cook, 2001a). To achieve the scale economies and impact needed to attract large incremental imports and to facilitate effective demonstrations that proportion is targeted to be maintained.

It is also estimated that a high proportion of the fertilizer is used on potato, with most of the remainder on vegetables/fruit. That is turn assumes a high percentage of fertilizer used in Ruhengeri and Gisenyi, a concentration on potatoes in these two districts and the high rate of return to fertilizer on potato. Vegetables are typically one of the first crops to be fertilized, as also seems the case in Rwanda. That dominance is assumed to remain for the first two years, at which point the highly profitable fertilization of maize is projected to rise. The two northwest provinces are also important producers of maize. As potato income rises, on farm consumption of maize will rise, and as livestock numbers rise some feeding is likely to occur.

Note that these numbers call for a 63 percent increase in imports in the first phase in year, an 85 percent increase in the second phase in year, and a 63 percent increase in the first year of 5000 ton increments. After that the annual percent increase drops off to about 23 percent increases each year.

In the first year of the phase in period, the target for coffee/tea was completely missed due to major problems in the parastatals. That is most unfortunate. For other crops, the target was mostly met. For the second year, it appears that demand growth is slackening. That seems to be entirely due to slow progress on demonstrations. The demonstration bottleneck will become more serious with each successive year.

It is assumed that as demonstrations are made routine in the two northwestern provinces that an intensive effort will be made in Kigali rural. This province has major potential for fertilizer use given the

concentration of importers in Kigali city, the influence of urban employment in reducing the credit constraint, and the strong urban demand, particularly for vegetables/fruits.

It should be noted however that Butare has a strong potential to come up given the location of the University and ISAR with strong extension programs contemplated in that province. Similarly Kibuye, with its substantial potato concentration might come up. Sorghum for beer may become important in the provinces near breweries, and so on. The critical point is to start where scale economies and initial success are likely, then move to other areas with potential for success and eventually attain national coverage. Of course, programs will have national coverage, here the argument is for concentration of extra effort where it will pay off quickly.

Tables 4, 5 and 6

Table 4 is based on data from Edson Mpyisi for the distribution of land and farmers by size of farm, and demonstrates that the targets can be achieved in Ruhengeri and Gisenyi without participation of any farmers with less than 0.5 hectares of land. That encompasses 36 percent of the land owning households and 69 percent of the land. Obviously including the 31 percent of land omitted would not only improve equity, but would add measurably to the growth rate as well.

Table 5 illustrates the feasibility of the fertilizer targets in Ruhengeri and Gisenyi and then Table 6 does the same for Kigali-Rural, both in a context of poorly developed credit programs. It is commonly stated that Rwanda farmers are too poor to finance fertilizer. However, the larger farmers generate incomes a substantial multiple of average incomes. Obviously the implication of leaving out the small farmers is undesirable from an equity point of view as well as for growth. The growth rate is obviously faster with full participation of all the land and farmers.

In Kigali Rural, it is assumed that participation will carry down to the smallest farmers due to the greater availability of urban employment, thereby releasing the credit constraint.

Table 7

Table 7 contains regional data from the FAO for potato production during the period 1990-2000 (FAO, 2001). The reduced production in Rwanda and Burundi has been more than balanced by increased production in picked up Kenya and Uganda.

Table 8

Table 8 takes the agricultural growth rate and calculates the impact of that growth on the rural non-farm sector and then the impact of those two sectors and two urban sectors on employment growth. It should be emphasized that national income accounts are not kept in a manner that allows easy separation of the rural non-farm sector from agriculture or even the urban non-formal sector from the urban formal sector. That is despite the dominance of the rural non-farm and the urban nonformula sector in employment generation.

GDP Base Proportions

Ministry of Finance and Economic Planning statistics report that 40 percent of GDP is generated in agriculture (Cook 2001a). The problem is then to divide the rest between rural non-farm, urban formal and urban non-formal.

Micro data provide a basis for estimating the GDP in the rural non-farm sector. MSU data from pre-genocide show 24 percent of farm gross income spent off farm. That would represent 9.6 percent of GDP. Essentially all of that would be spent locally in a country as poor as Rwanda. If we assume that marketing charges are 30 percent of the value of marketed output (Loveridge, 1992) and half of that is spent locally, that comes to 2.45 percent of GDP (.30x9.6x0.5). The multiplier of 2 provides 2.9. The sum of 9.6, 2.9 is 12.5 percent of GDP. If the rural non-farm sector spends half its incremental income within that sector, that would provide a multiplier of two, totaling 25 percent of GDP in the rural non-farm sector.

That leaves 35 percent of GDP in the urban sector. While the definition of farm and rural non-farm are self evident, the distinction is less clear between urban formal and non-formal sectors. Conceptually the formal sector is large scale, capital intensive, and derives its income exogenously from agriculture, and presumably at the margin from exports. Thus, urban formal would include the export industries and the sectors directly serving those industries such as electric power, finance, insurance and the like. In effect government would be seen as largely exogenous of agriculture and so it is included in the urban formal sector.

The urban non-formal sector is the labor intensive, small-scale firms, particularly those producing consumer goods that, like the rural non-farm, largely produces non-tradable goods and services and hence relies on domestic demand for its growth.

Assume that only five percent of urban income goes to labor (the rest is return to capital including human capital, that is the educated portion of labor income) and that half of that incremental incomes spent on the non-formal sector and similarly for the spending of the urban non-formal sector on itself, then the urban no-formal sector represents two percent of GDP (33x.05x.5x2=1.65, rounded up to 2.)

In practice, in Rwanda a significant share of urban activity relates to agricultural incomes. That is particularly so if we count ten percent of the population as urban. Since six percent of the population is in Kigali, that means that 40 percent of the urban population is in small cities like Butare and smaller. Those urban areas are substantially dependent on farm incomes for demand for their goods and services.

In the foregoing it is important to keep in mind that the proportion of GDP in agriculture is a firm figure from national income accounts; likewise the proportion of GDP in the rural non-farm sector is a firm figure built from the expenditures of rural people from pre genocide MSU farm surveys. Likewise the division of labor force between urban and rural and the size of the farm population. Thus, the data base is weak for division of the urban sector into the tradable and non-tradable sub-sectors. For employment the division is of only a total of 10 percent of the labor force, thus just how that divides is not very important to the results. For GDP there is a somewhat firm basis for attributing only a small proportion to the non-tradable sector on the basis of the modes proportion of urban income that goes to those who spend on the non-tradable sector. Finally, the ratio of GDP to employment in the rural and urban non-tradable sectors is

comes out about the same. Thus, the breakdown of GDP and employment by sector is quite well supported for major portions and the rest meets and consistency check, as stated. Most important the rural non-farm sector is very large compared to the urban non-tradable or non-formal sector because the urban sector in total is so small.

It is also notable that the factor shares to labor are extremely low for three reasons: (1) labor is paid a very low wage, the labor share of income will be far lower than one would expect from the physical capital to labor rations; (2) urban wage rates are far higher than rural wage rates b because of the return to human capital, which is quite highly paid compared to unskilled labor, and in these analyses human capital is counted as capital an d not heavily spent on non-tradables; (3) while some of urban tradable production is in industries that are only moderately capital intensive, other parts, such as much of transport, and power are extremely capital intensive.

Employment Base Proportions

Michigan State data from the pre genocide period state 0.5 hectares as providing full time employment for a family labor force. Here we make an assumption that somewhat inflates the size of the farm labor force by assuming that all farmers with more than 0.25 hectares are either full time farmers or less than full time by the amount of farm work done by those under 0.25 hectares. That is that the break for full time farming is at 0.25 hectares. That provides 40 percent of the labor force as full-time farmers. Assuming g further that all farmers with more than 1 hectare of land hire a full-time equivalent of hired labor adds another 4 percentage points to the full-time agricultural labor force. That is a total of 44 percent of the total labor force.

Given that 90 percent (rounded from 91 percent in the National Income Accounts) of the labor force is stated as rural in the National Income accounts, that le aves 46 percent of the labor force as rural non farm (MINECOFIN, 2000).

The urban labor force is arbitrarily divided equally between the formal and non-formal sectors. That provides a similar ratio of the labor force to GDP proportions in the urban and rural sectors.

GDP Growth Rates

The growth rate of 5.3 percent for agriculture is taken from Tables 1 and 2. The growth rate for the rural non-farm sector is calculated assuming an income elasticity of demand for rural non-farm goods and services of 1.5, consistent with studies by Mellor (1995) on the agricultural to non-agricultural multiplier and similar work by Hazell and Roell (Hazell and Roell 1983), Delgado et al (Delgado et al 1998) and Bell, Hazell and Slade (Bell, Hazell and Slade 1982). Thus the rural non-farm growth rate is the agricultural growth rate per capita (that is minus the population growth rate) times 1.5 plus the population growth rate: (5.3 - 2.5)1.5 + 2.5 = 6.7. Note that the rural non-farm sector is entirely driven by agricultural income growth and grows considerably faster than agriculture. That is what the economic transformation is all about.

The urban formal sector is arbitrarily assumed to grow at the fast rate of seven percent. The urban non-formal sector is assumed to be driven by the urban formal sector with the same relationships as the agriculture driven rural non-farm sector: (7.0 - 2.5)1.5 +2.5 = 9.2.

Elasticity of Employment With Respect to GDP Growth Rate

The elasticity for agriculture is moderately low at 0.6. Empirical studies of the green revolution (e.g. Rao, 1975) report elasticities between 0.6 and 0.3. The lower figure is for situations in which real wage rates are rising inducing specific attention to raising labor productivity (Rao, 1975). Technological change that raises crop yields, the type espoused here, also increase labor productivity.

The rural non-farm sector expands not through technological change as for agriculture, but through increased demand. An elasticity of 0.9 is used. That is slightly less than 1.0, which represents no increase in labor productivity. Thus, labor productivity increases minimally. With its faster growth and high employment elasticity the rural non-farm sector expands employment at a very rapid rate when agriculture is growin g rapidly.

The urban formal sector is driven by exports, is subject to vigorous international competition and must constantly increase productivity to compete. Thus, employment elasticities show in the literature as low, averaging 0.4. That is why urban growth tends to do little to reduce poverty, per Ravallion, Timmer, and Mellor (Ravallion 1995 , Timmer 1997, Mellor 1995).

Like the rural non-farm sector, the urban non-formal sector responds to increased demand with little increase in labor productivity and thus is assumed to have an elasticity of 0.9 like the rural non-farm sector.

Applying the elasticities to the GDP growth rates gives the employment growth rates. Weighting by the employment shares provides the average employment growth rate of 5.0.

The share of employment in each sector is calculated by taking the weight times the growth rate and taking each of those as a percent of the total. The share of GDP growth is calculated similarly.

References

Ahluwalia, Montek S. (1978). "Rural Poverty and agricultural performance in India," *Journal of Development Studies*, 14: 298-323.

Bell, C. L., & Hazell, P. B. R. (1980) "Measuring the indirect effects of an agricultural investment project on its surrounding region," *American Journal of Agricultural Economics*, 62: 75-86.

Bell, C. L., Hazell, P. B. & Slade, R. (1982) "Project evaluation in regional perspective: A study of an irrigation project in northwest Malaysia," Baltimore, MD: Johns Hopkins University Press.

Clay, Dan et. al. (2001) *Input Use and Conservation Investments Among Farm Households in Rwanda, Patterns and Determinants,* Unpublished manuscript, Michigan State University, East Lansing.

Cook, Andy, ed. (2002a) "Fertiliser Use and Marketing Policy Workshop Proceedings," Agricultural Policy Development Project, Research Report No. 10, Bethesda, MD: Abt Associates Inc.

Cook, Andy (2002b) "Fertiliser marketing and distribution in Rwanda." in "Fertiliser Use and Marketing Policy Workshop Proceedings," Agricultural Policy Development Project, Research Report No. 10, Bethesda, MD: Abt Associates Inc.

_____. (2002c) "Fertiliser imports and the import system." in *Fertiliser Use and Marketing Policy Workshop Proceedings*, Agricultural Policy Development Project, Research Report No. 10, Bethesda, MD: Abt Associates Inc.

Crissman, Charles (2002) "A Proposal for a Rwanda Potato Sector Development Program" Agricultural Policy Development Project, Research Report No. 17, Bethesda, MD: Abt Associates Inc.

Datt, G. & Ravallion, M. (1998) "Why have some Indian states done better than others at reducing rural poverty?" *Economica*, 65, 17-38.

Delgado, C. et al. (1998) "Agricultural Growth Linkages in Sub-Saharan Africa," Research Report No. 107, Washington, DC: International Food Policy Research Institute.

Desai, Gunvant M. (2002a) "Sustainable Rapid Growth of Fertiliser Use in Rwanda: a Strategy and an Action Plan" in *Fertiliser Use and Marketing Policy Workshop Proceedings*, Agricultural Policy Development Project, Research Report No. 10, Bethesda, MD: Abt Associates Inc.

Desai, Gunvant M. (2002b) "Key Issues In Achieving Sustainable Rapid Growth Of Fertilizer Use In Rwanda" Agricultural Policy Development Project, Research Report No. 16, Bethesda, MD: Abt Associates Inc.

Goossens, Frans (2002) "Potato Marketing in Rwanda" Agricultural Policy Development Project, Research Report No. 12, Bethesda, MD: Abt Associates Inc.

FAO (2001) FAOSTAT Database. Data retrieved on May 31, 2001 from FAOSTAT database on the World Wide Web: http://apps.fao.org/

Harris, J. and M. P. Todaro (1970) "Migration, Unemployment and Development: a Two-Sector Analysis," *American Economic Review*, 60: 126-42.

Hazell, Peter B.R. and Ailsa Roell. (1983) "Rural Growth Linkages: Household Expenditures Patterns in Malaysia and Nigeria," Research Report No. 41, Washington, DC: International Food Policy Research Institute.

Kelly, V. et al. (2002). "Fertiliser Consumption in Rwanda: Past Trends, Future Potential, and Determinants," in *Fertiliser Use and Marketing Policy Workshop Proceedings*, Agricultural Policy Development Project, Research Report No. 10, Bethesda, MD: Abt Associates Inc.

Loveridge, Scott (1992) "Sources of Agricultural Household Revenue, Exports, and Their Impact on Food Availability in Rural Rwanda" July, Kigali, Rwanda: Ministry of Agriculture and Livestock, Division of Agricultural Statistics.

Mellor, John W. and Lele, U. (1965) "Alternative Estimates of the Trend in Indian Foodgrains Production During the First Two Plans," *Economic Development and Cultural Change*, 13:217-235.

_____ and G. M. Desai. (1985) *Agricultural Change and Rural Poverty*, Baltimore, MD: Johns Hopkins University Press.

_____. (1995) *Agriculture on the Road to Industrialization.* Baltimore: Johns Hopkins University Press.

_____ and S. Gavian. (1999) "Determinants of Employment Growth in Egypt: The Dominant Role of Agriculture and the Rural Small-Scale Sector," Impact Assessment No. 7, Agricultural Policy Reform Project, Bethesda, MD: Abt Associates Inc.

_____. (2000a) "Pro-poor growth: Strategic elements for CILLS," Rural and Agricultural Incomes With A Sustainable Environment (RAISE) project, November, Bethesda, MD: Abt Associates Inc.

_____. (2000b) "Agricultural growth, rural employment, and poverty reduction - Non-tradables, public expenditure, and balanced growth," Paper presented at the World Bank Rural Week 2000, Poverty or Prosperity: Rural People in a Globalized Economy, March 28-31, 2000.

_____. (2001) "Meeting the OECD Poverty Targets: An Approach Paper for USAID," Agricultural Policy Development Project, Research Report No. 3, Bethesda, MD: Abt Associates Inc.

_____. (2002) "Productivity Increasing Rural Public Works - An Interim Approach to Poverty Reduction in Rwanda" Agricultural Policy Development Project, Research Report No. 15, Bethesda, MD: Abt Associates Inc.

_____ and C. Ranade (2002a) "The Impact of Agricultural Growth on Employment in Rwanda: A Three-Sector Model" Agricultural Policy Development Project, Research Report No. 14, Bethesda, MD: Abt Associates Inc.

_____ and C. Ranade (2002b) "Modeling Egyptian Employment with a Three-Sector Model – Agriculture, Non-Tradables, and Urban Tradables," Impact Assessment Series, Agricultural Policy Reform Project, Bethesda, MD: Abt Associates Inc.

MINAGRI (2001). Agricultural Statistics. Retrieved May 31, 2001 from the World Wide Web: http://www.rwanda1.com/government/.

MINECOFIN (2000). Rwanda Development Indicators. Kigali, Rwanda.

Mpyisi, E. et al. (2000) "Food Security Survey: Phase I: Agricultural Production and Land use Season A," Kigali, Rwanda: Ministry of Agriculture, Animal Resources, and Forestry.

Rao, C. H. H. (1975) *Technological Change and Distribution of Gains in Indian Agriculture.* Delhi: Macmillan.

Ravallion, M. (1995) "Growth and Poverty: Evidence for the Developing World," *Economics Letters.*

Timmer, P. C. (1997) "How well do the poor connect to the growth process?" CAER II Discussion Paper No. 17, Cambridge, MA: Harvard Institute for International Development.